REMARKS

Claims 1-56 are pending in the application. In view of the following remarks, Applicant traverses the Office's rejections and respectfully requests that the application be forwarded on to issuance.

The Claim Rejections

Claims 1-56 stand rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 6,208,347 to Migdal. Preliminarily, Applicant submits that the Office's rejection is improper as Migdal does not constitute prior art under §102(b). According to this section of the Patent Statute, prior art consists of patents and publications in this or a foreign country that existed more than one year prior to the date of the application. Migdal's issue date is March 27, 2001. Applicant's filing date is November 29, 1999. Accordingly March 27, 2001 is not one year prior to November 29, 1999 and, as such, Migdal is not §102(b) prior art.

Nonetheless, in the spirit of advancing prosecution of the application along, Applicant addresses the Office's rejections below.

Applicant's Disclosure

Before addressing the substance of the Office's rejections, the following description and explanation of Applicant's disclosure is provided in an attempt to illustrate ways in which the subject matter in Applicant's disclosure differs from Migdal's disclosure.

Consider first the problem that Applicant's disclosure addresses. Specifically, Applicant's disclosure is directed to a more optimal approach in the field of ray intersection in which a ray is cast toward object. A majority of the

processing that takes place in connection with ray intersection concerns searching for an object that is intersected by a cast ray. Typically, surfaces of objects are approximated by a plurality of shapes such as triangles and other polygons. Conventional searching techniques typically determine whether or not each and every shape that constitutes the approximated surface of an object is intercepted by the cast ray. For example, if the surface of an object is approximated by 6500 triangles, conventional searching algorithms test a first triangle to determine whether the cast ray intercepts it. If the first triangle is not intercepted by the cast ray, then the next triangle is tested and so on. Needless to say, processing each of the shapes used to approximate the surface of an object, while effective, is not the most optimal approach to the problem.

Applicant's disclosure describes approaches in which the total number of shapes that are typically evaluated by the conventional algorithms for an intersection is significantly reduced prior to evaluation. This reduction of the number of shapes to be evaluated is achieved by pre-characterizing aspects of the individual shapes that make up an object. Through pre-characterization processing, a sub-set of possible intersected shapes, which has a smaller number of shapes than the total number of shapes that approximate the surface of the object, is defined, with such sub-set being subsequently evaluated to ascertain those shapes within the sub-set that are intersected by the defined ray. Reducing the number of shapes that are evaluated for ray intersections greatly reduces the processing overhead thereby improving processing times. Improvements over conventional processing techniques have been observed on the order of 5- to 10-times faster.

As a specific example that illustrates one of Applicant's embodiments in action, consider Applicant's Figs. 7-10 appearing directly below.

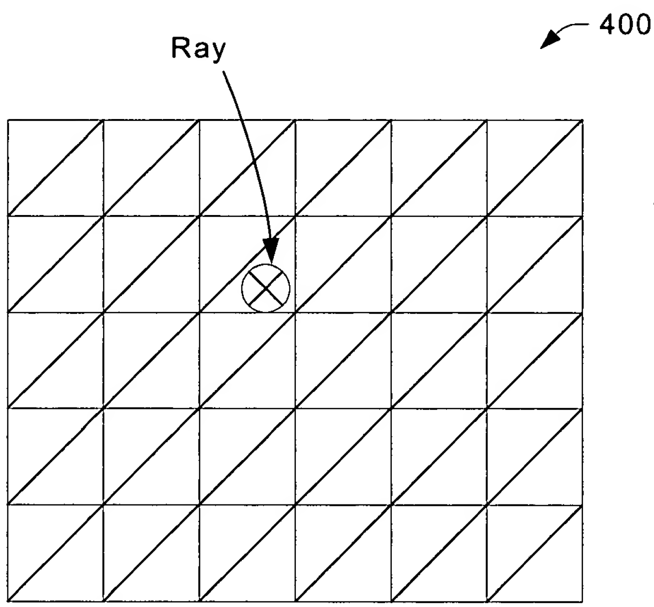

Fig. 7

Fig. 7 shows a collection of shapes 400 that comprise a triangle mesh approximating an object of interest. In this particular example, the collection constitutes 60 surfaces (each triangle comprising one surface) and 42 vertices. In the past, intersection algorithms have evaluated ***each*** of the separate triangles of the illustrated collection to determine whether there is an intersection with a cast ray. So, in this case, conventional methods might have started with the first triangle in the first column, evaluated it for an intersection, and then discarded it when there was no intersection. This method would then step through each of the triangles, similarly evaluating them for an intersection with the ray. With complex surfaces having a high degree of resolution (i.e. many shapes), processing overhead can be quite large. Advantageously, the described embodiment reduces

the number of shapes that must be tested for an intersection. This saves greatly on processing overhead and increases the speed with which objects are processed.

Fig. 7 shows a ray that has been cast toward the object that is approximated by collection 400. The ray extends into and out of the plane of the page upon which Fig. 7 appears.

Fig. 8, appearing directly below, shows a plane containing the ray that is perpendicular to the page upon which Figures 7 and 8 appear.

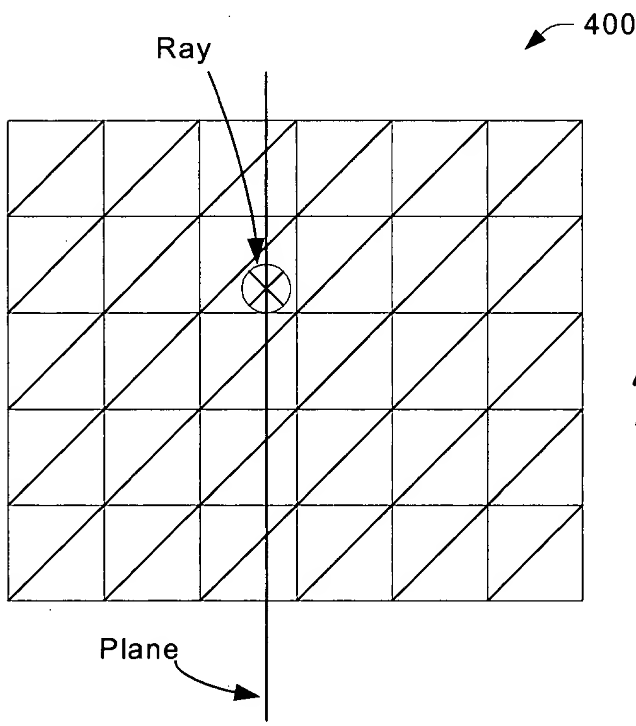

Fig. 8

Fig. 9 shows a sub-set of shapes (shaded for clarity) that might be intersected by the ray. Here, an evaluation has been performed to determine whether the triangle(s) that are defined by the individual vertices straddle the defined plane. If they do straddle the defined plane, then it is *possible* that they are intersected by the ray. Here, the number of triangles that have to be evaluated by an intersection algorithm have been reduced from 60 to 10.

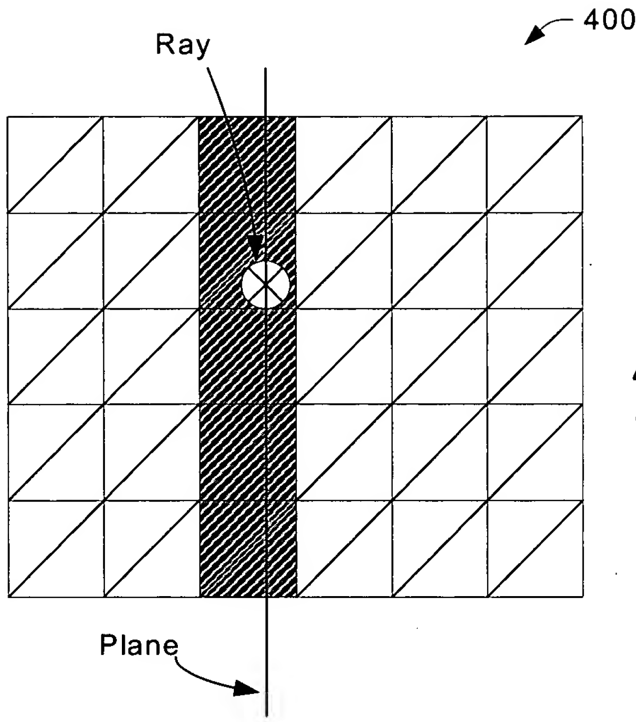

Fig. 9

Fig. 10 shows collection 400 after the intersection algorithm has been run on all of the triangles in the shaded sub-set of Fig. 9. In this example, only one triangle (shaded for clarity) is intersected by the ray.

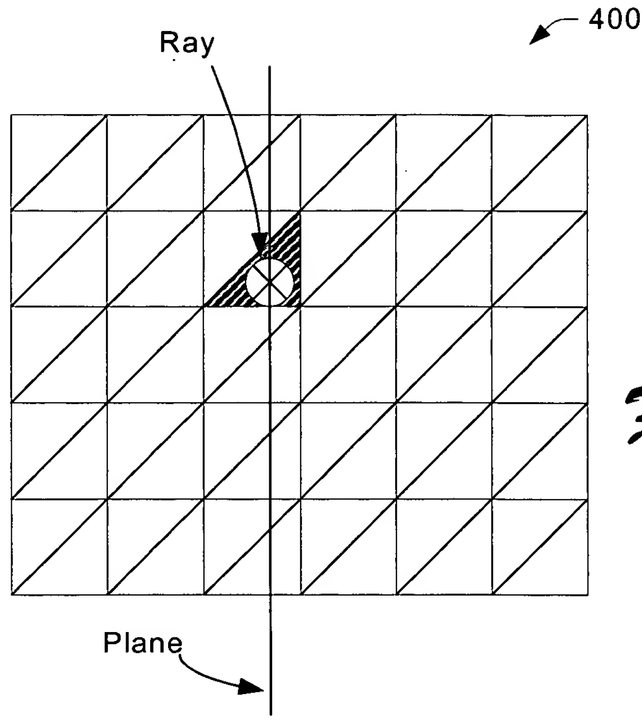

Fig. 10

<u>Migdal's Disclosure</u>

Migdal's disclosures pertains to systems and methods for modeling 3D objects and 2D images by wireframe mesh constructions having data points that ***combine both spatial data and surface information such as color or texture data***.

Migdal's disclosure is not at all directed to methods and systems that utilize or otherwise provide improved methods and systems for ray intersection as described in Applicant's disclosure. Rather, Migdal's systems and methods use complex data points (e.g., X, Y, Z, R, G, B in 3D and x, y, R, G, B in 2D) and allow the modeling system to incorporate both the ***spatial features*** of the object or image as well as its ***color or other surface features*** into the wireframe mesh. Migdal's 3D object models (such as those created by laser scanning systems) do not require a separate texture map file for generating display or other object manipulations. Hence, Migdal's approach is directed to improving modeling

methods by eliminating the need for a separate texture map file which, in the past, consumed valuable memory resources.

A thorough reading of Migdal's disclosure reveals that it does not even remotely concern the same problem with which Applicant's disclosure is concerned. Accordingly, Migdal's systems and methods present solutions which utilize elements that simply do not make any sense in the context of Applicant's disclosure. For example, in one of Migdal's embodiments, the mesh constructions contain sufficient color information such that the triangles of the meshes can be rendered by any processor supporting linear or bilinear interpolation such as Gouraud shading (available in many 3D and 21/2D systems). For 2D systems (such as digitized photographs, film frames, video frames and other bitmap images) the 2D mesh models created from the teachings of Migdal's invention replace bitmap files and present a greater level of data compression and flexibility in image manipulation than is currently available in compression systems such as JPEG. In addition, Migdal's modeling system has dynamic resolution capability, such that surface details like color or texture can be rapidly added or subtracted from the model.

Migdal's subject matter has nothing whatsoever to do with Applicant's methods and systems that utilize or otherwise provide improved methods and systems for ray intersection, as described in Applicant's disclosure.

In the discussion that follows, Applicant specifically addresses each of the Office's arguments with respect to the claim rejections. In view of the following discussion, Applicant respectfully traverses the Offices rejections.

The Office's Arguments

Claim 1 recites a method for determining which shapes are intersected by a ray in a computer graphic processing system in which a ray is cast toward an object represented by a collection of pre-determined shapes each characterized by characteristic data. Accordingly, the method recites:

- defining a reference object relative to the represented object;
- determining the positions of the shapes relative to the reference object using the characteristic data; and
- determining, on the basis of the positions of the shapes relative to the reference object, those shapes that have no chance of intersecting the ray, and those remaining shapes that may intersect the ray.

In making out the rejection of this claim, the Office argues that Migdal discloses "defining a reference object relative to the represented object" and cites to column 42, lines 47-51 in support therefore. That section of Migdal states as follows:

> The process in step 717 places references to each altered point and the associated face and new faces are placed in the recalculation list (712). The recalculation list for this process is constructed as a stack for later processing.

This disclosure does not describe or in any way suggest defining a reference object relative to a represented object, as understood in the context of Applicant's disclosure. Rather, this excerpt from Migdal simply describes one aspect of its processing which, as noted above, is completely different from Applicant's disclosure. For a complete understanding of the context in which the excerpted portion of Migdal is used, reference is made to column 41, lines 55 through column 42, line 67, the entirety of which is set forth below:

Referring to FIG. 24, the processor creates an initial mesh into which it will insert data points from the bitmap image to create the mesh (step 700). In the exemplary embodiment, the initial mesh will have a two triangle configuration made from four points which match or exceed the bounds of the image. For example, if a bitmap image is of size 640.times.480 in dimension, the X, Y coordinates of the initial mesh (stored in a data structure equivalent to the 6D data point list above) will be sized to contain that image. The four selected points will create a flat, rectangular plane consisting of two triangles. Additionally, the mesh structure can include one or more Steiner points outside of the bounds of those four points to speed processing. For each of the initial four points of the plane mesh, the processor will also select R, G, B coordinates for the initial mesh data points so that the mesh has an initial color which will serve as the point of comparison when determining whether to add R, G, B values from the bitmap image.

In step 702, the processor begins a loop (steps 704, 706, 710, 711, 712, 714, 716) to incrementally insert points and construct a 5D data point mesh for a 2D bitmap image. In step 702, the processor will incrementally insert data points according to any user-defined threshold. For example, the processor may insert points until the mesh contains the desired number, or until the comparison distance between any bitmap pixel point and its counterpart in the mesh fall below a given threshold, the "comparison distance" being the distance between the colors of the pixels of the bitmap image and the area of the mesh triangle which corresponds to that pixel. The rasterization process uses the R, G, B values of the mesh triangle to generate, a la Gouraud, a set of color values that correspond to each pixel in the bitmap image which would be bounded by the mesh triangle, pixel by pixel, within the bounds of the triangle. The process compares the R, G, B values of the bitmap pixel against the corresponding R, G, B value rasterized from the coordinates of the mesh triangle. The difference between the bitmap and rasterized R, G, B values can be measured by many difference functions such as by:

[equations omitted]

Where d.sub.R, for example, denotes the difference in red coloring between the actual pixel and the Gouraud approximation, and where L.sub.R, for example, denotes the luminescence value of the color red.

In the rasterization step 708, the process compares each pixel value in the bitmap with a corresponding rasterized value until for that triangle

> the processor finds the pixel with the largest distance value. In step 710, the processor inserts the bitmap data point into the mesh triangle using the process described above with regard to the incremental insert function. The insertion of the new point alters the mesh face into which a bitmap point was inserted. The insertion also creates two new faces. The process in step 717 places references to each altered point and the associated face and new faces are placed in the recalculation list (712). The recalculation list for this process is constructed as a stack for later processing. This allows faces where there have been substantial insertion activity to be processed first. After the point insertion, the processor proceeds to step 714 to check the mesh structure for optimal construction using, e.g., Delaunayian checking routines as described above. For each flip made during the checking procedure, the processor places an indication of that change on the history list 152. In addition, if the flipping process changes any face, the processor will place a reference to that face on the recalculation list (step 720).
>
> In step 718, the processor loops to step 704 where it will process each face inserted on the recalculation list stack. The process continues until the process has inserted the desired number of points or until the resolution of the mesh has increased until the distance between any bitmap data point and its rasterized mesh counterpart does not surpass a set threshold.

It is apparent from this passage that what Migdal describes does not amount to defining a reference object relative to a represented object, as such is used in the context of claim 1.

With respect to the next claim limitation (i.e. “determining the positions of the shapes relative to the reference object using the characteristic data”), the Office argues that Migdal discloses such, and cites to column 25, lines 3-10 in support therefore. That section of Migdal states as follows:

> There are functions available to generate their point values through rasterization, such as the "draw scan line" left functions. In addition, FIG. 8 presents a loop which processes X, Y, Z values for each u position moving from the left to the right along the scan line. For each u increment, the processor creates X, Y, Z values and loads them into the 6D data point list 142 using the dXdu, dYdu and dZdu delta values (step 224).

It is unclear to Applicant, at best, how this excerpted portion of Migdal even remotely anticipates the above-mentioned claim limitation. This is particularly so given that the Office appears to be taking the position that a "reference object" in Migdal is the reference that is placed in its recalculation list.

For a complete understanding of the context in which this excerpt is used, reference is made to column 23, line 63 through column 25, line 36, the entirety of which is set forth below:

> FIG. 8 depicts an exemplary process flow for ***generating points according to a rasterization process***. The process of FIG. 8 generates a full set of 6D (X, Y, Z, R, G, B) values from the available spatial and texture data. In step 200, the processor begins a loop that will rasterize X, Y, Z coordinate values for the associated texture map pixels with a mesh triangle. The processor accesses the triangle information from an initial mesh data structure created by the process in step 170. In step 202, the processor gets the next available triangle.
>
> In step 204, the processor locates the u, v links that each vertex in the mesh triangle has as a reference to a corresponding point in the texture map file. As noted above, to locate the texture map pixels, the processor uses the (u, v) links that each vertex in the mesh triangle has to a pixel value in the texture map file. If the spatial and object modeling data has been obtained from a scanning system, that data was obtained simultaneously from the same camera and the X,Y values of the 3D spatial coordinates of each vertex will match the u, v 2D coordinates of a designated bitmap image in the texture map file 2b.
>
> In step 206, the processor determines from the u, v texture map coordinate values the minimum and maximum texture map coordinates vmax and vmin for the three triangle vertices. As the pixels in the texture map are arranged in "scan line" rows corresponding to v, each v scan line will contain R, G, B coordinate values for each u. The rasterization process will loop through each v scan line creating X Y, Z values for the corresponding R, G, B values. The umin and umax values are used for rasterizing those values determined for later processing.

In step 208, the processor loops to calculate, for each edge of the texture map triangle found by the three u, v coordinate values, the change in X, Y, Z for each change in the v value and the change in X, Y, Z for each change in the u value. For each edge, the processor, in step 210, computes:

```
dv          du
dXdv        dXdu
dYdv        dYdu
dZdv        dZdu
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In this step, the processor also arranges the edges to identify the two edges that have the vmin value. It is from that part of the triangle that the rasterization process will begin.

In step 212, the processor begins a set of processes to set the edge values between which the processor will compare the X, Y, Z values. For each v line of pixels, the processor will need to establish a right and left u position and a corresponding X, Y, Z value. As the v scan lines change the X, Y, Z values will change following the dv values. Along each u scan line the X, Y, Z values will change along the du values. In step 212, the processor sets the right and left edge points at the outset to be the shared endpoint of the edges (right and left) which share the vmin value. Next, the processor proceeds to step 214 to establish a stepping factor for each of the variables based on the delta values, dXdv, dYdv, dZdv and dZdv for each scan line step through the pixel values.

In step 216, the processor begins a loop to process the pixels in the scan line. The loop processes each scan line from vmin to vmax. The first step is to begin a check on the edges which use the vmin value to see if they have not run out (step 218). If either the right or left edge has run its length, and the v scan line is beyond it, the processor will swap the third edge with that edge.

In step 220, the processor establishes the boundary of right and left edges along the v scan line and the X, Y, Z values that are associated with it. The step uses the dv values to establish a left edge u point and a right edge u point and the associated X, Y, Z values. With the right and left edge of the scan line established, the processor can now generate in X, Y, Z value for each texture map coordinate R, G, B value.

There are functions available to generate their point values through rasterization, such as the "draw scan line" left functions. In addition, FIG. 8 presents a loop which processes X, Y, Z values for each u position moving from the left to the right along the scan line. For each u increment, the

processor creates X, Y, Z values and loads them into the 6D data point list 142 using the dXdu, dYdu and dZdu delta values (step 224).

In step 226, the processor loops to step 222 and continues processing X, Y, Z values for each u position in the current scan line. The processor loops in step 228 to step 216 to process another scan line. When each scan line for the triangle has been processed, the processor loops in step 230 to step 200 and processes the next triangle until all triangles have been processed.

The rasterization process described in FIG. 8 generates one X Y, Z spatial coordinate for each texture map coordinate. As stated above, there are situations when it would not be advantageous to generate for each texture map coordinate a corresponding X, Y, Z value. For these situations the present invention provides a system and method of generating 6D data points with some discrimination. The procedure functions very much like the procedure outlined in FIG. 8, except that in addition to processing delta values for dX, dY and dZ, the process would also process delta values for dR, dG and dB using the R, G, B values from the texture map that were associated with the original three mesh data points. The rasterized R, G, B could be compared against the actual R, G, B values in the texture map. If the difference between these points was greater than a threshold (as determined in a comparison step (before step 224 in FIG. 8 for example) then the processor would generate a X, Y, Z value and create a 6D data point. If the difference fell below a threshold, it would not.

Hence, what Migdal is describing is a rasterization process in which a full set of 6D values are generated from the available spatial and texture data. This process has nothing whatsoever to do with the recited processing that takes place relative to casting a ray toward an object represented by a collection of pre-determined shapes, as contemplated in claim 1.

With respect to claim 1's final limitation (i.e. "determining, on the basis of the positions of the shapes relative to the reference object, those shapes that have no chance of intersecting the ray, and those remaining shapes that may intersect the ray"), the Office cites to Migdal's column 7, lines 61-67 arguing that such

excerpt discloses this claim limitation. Applicant respectfully disagrees. The cited section of Migdal states as follows:

> With the mesh modeling system and method of the present invention, any rendering engine that supports linear or bilinear interpolation, such as "Gouraud Shading" (available in many 3D and 21/2/2D graphic systems), will accept the mesh data points of the present invention and output a high-quality depiction or reproduction of the object or image. The rasterization needed for generating the display can be done on the host processor (or for greater speed on special 3D hardware).

This passage neither discloses nor suggests "determining, on the basis of the positions of the shapes relative to the reference object, those shapes that have no chance of intersecting the ray, and those remaining shapes that may intersect the ray." This passage does not even mention a "ray" at all.

Applicant submits that claim 1 is independently allowable for any ***single*** reason discussed above with regards to the individual claim limitations. When the claim limitations are taken collectively, however, it is abundantly clear that Migdal in no way anticipates the subject matter of claim 1, or even remotely suggests claim 1's subject matter.

Claim 2 depends from claim 1 and is allowable as depending from an allowable base claim. This claim is also allowable for its own recited features which, in combination with those recited in claim 1, are neither disclosed nor suggested in the references of record, either singly or in combination with one another.

Claim 2 further recites "using a predetermined algorithm to determine which one of those remaining shapes intersects the ray." In making out the rejection of this claim, the Office cites to Migdal's column 14, line 24-29 in

support for its argument that Migdal anticipates this claim limitation. The cited section of Migdal states as follows:

> Algorithms for rendering, such as rasterization processes using Gouraud or Phong shading techniques, render mesh triangles in gradient color based on the color values contained in the 6D vertex coordinates of each face, so that a very life-like image of the object can be generated.

The recited subject matter pertains to using an algorithm to determine which of the remaining shapes intersects the ray. The algorithms mentioned in Migdal's excerpt pertain to those for rendering mesh triangles in gradient colors based on the color values contained in the 6D coordinates of each face. There appears to be no relation whatsoever between the subject matter recited in claim 2 and this excerpt from Migdal. Accordingly, for at least this additional reason, claim 2 is allowable.

Claims 3 and 4 recite that the collection of shapes comprises at least one polygonal shape and a plurality of polygonal shapes, respectively. In making out the rejection of these claims, the Office cites to Migdal's column 5, lines 54-58, and Fig. 10c. This section of Migdal states as follows:

> While such systems can optimize and change resolution, inter alia, they typically require large amounts of processing time to prepare the mesh or do not provide a reliable visual representation of the object when the mesh contains few polygons.

Claims 3 and 4 depend from claim 1 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited features which, in combination with those recited in claim 1, are neither disclosed

nor suggested in the references of record, either singly or in combination with one another. Additionally, given the deficiencies in the rejections of claim 1, this passage of Migdal is not seen to add anything of significance to the Office's rejections.

Claims 5 and 6 further define the subject matter of claim 1 and recite that the collection of shapes comprises, respectively, at least one triangle and a plurality of triangles. The Office's citation to Migdal's Figs. 10a-d does not add anything of significance to the deficiencies in the rejection of claim 1. Accordingly, these claims are allowable as depending from an allowable base claim, and for their own recited features which, in combination with those recited in claim 1, are neither disclosed nor suggested in the references of record, either singly or in combination with one another.

Claims 7-9 further define the collection of shapes recited in claim 1 as comprising, respectively, a triangle mesh, a triangle strip, and a triangle fan. The Office's citation to Migdal's Figs. 2c-g does not add anything of significance to the deficiencies in the rejection of claim 1. Accordingly, these claims are allowable as depending from an allowable base claim, and for their own recited features which, in combination with those recited in claim 1, are neither disclosed nor suggested in the references of record, either singly or in combination with one another.

Claims 10 and 11 further define the reference object of claim 1 to comprise, respectively, at least one plane and a plurality of planes each of which contain the ray. In making out the rejection of these claims, the Office cites to Migdal's Fig. 10d and argues that it depicts an initial mesh constructed from Steiner points where the initial reference object is a plane.

These claims depend from claim 1 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited features which, in combination with those recited in claim 1, are neither disclosed nor suggested in the references of record, either singly or in combination with one another. Additionally, given the deficiencies in the Office's rejections with respect to claim 1, the Office's reliance on Fig. 10d and the related discussion is not seen to add anything of significance to the rejections.

Claim 12 depends from claim 1 and further recites that the act of determining the positions of the shapes comprises determining positional aspects of sub-components of individual ones of the shapes to provide the characteristic data.

Claim 13 depends from claim 12 and further specifies that the individual shapes comprise polygons and the sub-components comprise vertices that define the polygons, and that the act of determining the positions of the shapes comprises computing the positions of the vertices relative to the reference object.

Claim 14 depends from claim 13 and further recites that the reference object comprises a plane.

Claim 15 depends from claim 14 and further recites that the plane is parallel to one of the *x, y,* and *z* axes.

In making out the rejections of claims 12-15, the Office cites to Migdal's column 3, lines 12-26; column 4, lines 4-11; and Fig. 10d.

Migdal's column 3, lines 12-26 is set forth just below:

> A scanning system uses a light source (such as a laser) to scan a real-world object and a data collection device (such as a camera) to collect images of the scanning light as it reflects from the object. The scanning

system processes the captured scan information to determine a set of measured 3D X, Y, Z coordinate values that describe the object in question. Some scanning systems can easily gather enough raw data to generate several hundred thousand 3D data point coordinates for a full wraparound view of an object. A typical 3D object modeling system processes the 3D point data to create a "wire-frame" model that describes the surface of the object and represents it as a set of interconnected geometric shapes (sometimes called "geometric primitives"), such as a mesh of triangles, quadrangles or more complex polygons.

Migdal's column 4, lines 4-11 is set forth just below:

> For models of real-world objects, texture data typically comes from 2D photographic images. The laser scanning systems described above can collect texture data by taking one or more 2D photographic images of the object in an ordinary light setting as they collect laser scan data. Thus, 3D scanning systems both scan an object with a laser to collect spatial data and photograph it to collect color and other surface characteristic information.

From a reading of these excerpts of Migdal, it is very clear that what Migdal is talking about is very different from the subject matter recited in claims 12, 12/13, 12/13/14, and 12/13/14/15. Accordingly, these claims are allowable as depending from an allowable base claim, and for their own recited features which, in combination with those recited in claim 1, are neither disclosed nor suggested in the references of record, either singly or in combination with one another.

Claim 16 recites a method for determining which of a collection of pre-determined shapes are intersected by a ray cast toward an object that is represented by the shapes. The method recites:

- defining a collection of polygons that approximate an object, individual polygons having a plurality of vertices;
- casting a ray toward the approximated object;

- defining a reference object relative to the collection of polygons and that contains the cast ray;
- pre-characterizing at least some vertices of at least some of the polygons to provide characteristic data that describes the vertices' positions relative to the reference object; and
- using the characteristic data to ascertain the positions of the individual polygons relative to the reference object.

In making out the rejection of this claim, the Office argues that Migdal discloses the first claim limitation (i.e. "defining a collection of polygons that approximate an object, individual polygons having a plurality of vertices") in column 17, lines 22-23; the second and third claim limitations (i.e. "casting a ray toward the approximated object" and "defining a reference object relative to the collection of polygons and that contains the cast ray") in column 5, lines 15-24; and the fourth claim limitation (i.e. "pre-characterizing at least some vertices of at least some of the polygons to provide characteristic data that describes the vertices' positions relative to the reference object" and "using the characteristic data to ascertain the positions of the individual polygons relative to the reference object") in column 25, lines 57-63.

As noted above, Migdal's disclosure is directed to methods that are very different from the methods described in Applicant's disclosure. For example, the specific content of Migdal's column 25, lines 57-63 and its context is discussed above. Accordingly, for the sake of brevity, it is not repeated here. It is important, however, to appreciate that Migdal is describing a rasterization process in which a full set of 6D values are generated from the available spatial and texture data. This is very different from, and is not to be confused with Applicant's recited subject matter which is directed to a method for determining which of a collection of pre-determined shapes are intersected by a ray cast toward

an object that is represented by the shapes. Accordingly, for at least this reason, this claim is allowable.

Claims 17-22 and 24-26 depend from claim 16 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited features which, in combination with those recited in claim 16, are neither disclosed nor suggested by the references of record, either singly or in combination with one another.

Claim 23 is rejected under §112, second paragraph, for apparently failing to correspond in scope with the discussion appearing in the Specification, page 10, line 19. Applicant submits that there is nothing improper about this claim and that it particularly points out and distinctly claims the subject matter which Applicant regards as the invention. The Office appears to be taking issue with the fact that the recited subject matter recites a "polygon", whereas one example in the Specification uses a triangle as the example. Applicant respectfully points out the discussion appearing on page 10, lines 1-9, which is provided in its entirety below:

> As shown, a collection of shapes is first defined to approximate an object in connection with a computer graphics program. In this example, the surface of the object is approximated by a collection of shapes. Fig. 3 shows an exemplary portion of such a collection generally at 300. ***Any suitable shapes can be used.*** In the described embodiment, the shapes have a similar geometry. ***Typically, polygons having a plurality of vertices are used.*** As will become apparent below, it is advantageous to select polygons that collectively have more faces than vertices when approximating the surface of an object. ***In the illustrated example, the polygons comprise triangles.***

Accordingly, Applicant discusses the fact that typically polygons have vertices. In the specific example given in the specification, one specific type of

polygon—a triangle—is used. Accordingly, in view of the fact that triangles are a specie of the genus of polygons, ***and*** Applicant clearly identifies in the specification that any suitable shapes or polygons (having corresponding vertices) can be used, there is no failure in correspondence between the subject matter claimed in claim 23 and the disclosure in Applicant's specification. Accordingly, Applicant respectfully traverses this claim rejection.

Claim 27 recites a method for determining which of a number of shapes that represent an object are intersected by a ray that is cast toward the object. The method recites:

- defining a plurality of triangles that approximate an object, individual triangles having three vertices;
- casting a ray toward the approximated object;
- defining at least one plane relative to the approximated object to contain the ray;
- pre-characterizing the vertices of the plurality of triangles to provide characteristic data that describes the positions of the vertices relative to said at least one plane; and
- using the characteristic data to ascertain the positions of the individual triangles relative to said at least one plane.

In making out the rejection of this claim, the Office states that this claim is rejected for the reasons given with respect to claims 16-26. It should be appreciated that claim 27 recites a method which is more specific, in some regards, than the method recited in claim 16, or any of its sub-combinations with its dependent claims. Accordingly, as claims 16-26 are allowable as noted above, claim 27 should be summarily allowed.

Claims 28-36 depend from claim 27 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited

features which, in combination with those recited in claim 27, are neither disclosed nor suggested by the references of record, either singly or in combination with one another.

Claim 37 recites a method for determining which of a number of polygons that represent an object are intersected by a ray that is cast at the object. The method recites:

- defining a sub-set of polygons from a collection of polygons that approximate an object by determining which polygons have vertices that satisfy a predefined relationship relative to a reference object; and
- evaluating the sub-set of polygons to ascertain which of the polygons is intersected by a cast ray.

In making out the rejection of this claim, the Office cites to Migdal's column 17, lines 19-25. This passage has nothing to do with the recited subject matter. As noted above, Migdal's methods are not directed to determining which of a number of polygons that represent an object are intersected by a ray that is cast at the object. As such, Migdal's methods cannot be said to disclose or even suggest defining a sub-set of polygons from a collection of polygons that approximate an object by determining which polygons have vertices that satisfy a predefined relationship relative to a reference object; and evaluating the sub-set of polygons to ascertain which of the polygons is intersected by a cast ray.

Accordingly, for at least this reason, claim 37 is allowable.

Claims 38-42 depend from claim 37 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited features which, in combination with those recited in claim 37, are neither disclosed

nor suggested by the references of record, either singly or in combination with one another.

Claims 41-42 are objected to as lacking an antecedent basis for the limitation "computer graphic processing". This limitation does not appear in claims 41 or 42. Claim 37 is directed to a method. Claim 41 is directed to a computer-readable media that has instructions which, when executed, implement the method of claim 37. Claim 42 is directed to a computer having memory that contains software code which causes its processor to execute the method of claim 37. This is nothing improper about these claims and there is no antecedent basis issue with either of the claims. Accordingly, Applicant respectfully traverses the Office's objection.

Claim 43 recites a computer graphic processing system comprising a programmable computer programmed with computer-readable instructions which, when executed by the programmable computer, implement the following method:

- defining a plurality of polygons that approximate an object, individual polygons having a plurality of vertices;
- casting a ray toward the approximated object;
- defining at least one plane relative to the approximated object to contain the ray;
- pre-characterizing the vertices of the plurality of polygons to provide characteristic data that describes the positions of the vertices relative to said at least one plane;
- using the characteristic data to ascertain the positions of the individual polygons relative to said at least one plane;
- determining which of the individual polygons might be intersected by the ray, based upon their ascertained positions, to provide a sub-set of polygons; and
- evaluating the sub-set of polygons to ascertain which of the polygons are intersected by the ray.

In making out the rejection of this claim, the Office argues that this claim is rejected for the same reason as was claim 37. For all of the reasons set forth above with respect to the allowability of claim 37, claim 43 is allowed.

Claims 44-47 depend from claim 43 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited features which, in combination with those recited in claim 43, are neither disclosed nor suggested by the references of record, either singly or in combination with one another.

Claim 48 recites one or more computer-readable media having computer-readable instructions thereon which, when executed by a computer graphic processing system, implement the following method:

- defining a plurality of triangles that approximate an object, individual triangles having three vertices;
- casting a ray toward the approximated object;
- defining at least one plane relative to the approximated object to contain the ray;
- pre-characterizing the vertices of the plurality of triangles to provide characteristic data that describes the positions of the vertices relative to said at least one plane;
- using the characteristic data to ascertain the positions of the individual triangles relative to said at least one plane;
- determining which of the individual triangles might be intersected by the ray, based upon their ascertained positions, to provide a sub-set of triangles; and
- evaluating the sub-set of triangles to ascertain which of the triangles are intersected by the ray.

In making out the rejection of this claim, the Office states that the claim is rejected for the reasons set forth with respect to claim 16. For all of the reasons set forth above with respect to the allowability of claim 16, this claim is allowable.

Claim 49 depends from claim 48 and is allowable as depending from an allowable base claim. This claim is also allowable for its own recited features which, in combination with those recited in claim 48, are neither disclosed nor suggested by the references of record, either singly or in combination with one another.

Claim 50 recites a computer graphic processing system comprising:

- a processor;
- memory; and
- software code stored in the memory that causes the processor to implement a ray-intersection algorithm which:
- casts a ray at a collection of shapes that approximate an object;
- defines a reference object that contains the ray;
- pre-characterizes aspects of individual ones of the shapes of the collection to provide characteristic data; and
- uses the characteristic data to ascertain the position of the shapes of the collection of shapes relative to the reference object.

In making out the rejection of this claim, the Office cites to Migdal's Fig. 1 and the related discussion in Migdal's specification. Applicant submits, for all of the reasons set forth above, that there is nothing in Migdal that discloses or suggests the subject matter of this claim. Accordingly, for at least this reason, this claim is allowable.

Claims 51-56 depend from claim 50 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited features which, in combination with those recited in claim 50, are neither disclosed nor suggested by the references of record, either singly or in combination with one another.

Conclusion

All of the claims are in condition for allowance. Accordingly, Applicant requests a Notice of Allowability be issued forthwith. If the Office's next anticipated action is to be anything other than issuance of a Notice of Allowability, Applicant respectfully requests a telephone call for the purpose of scheduling an interview.

Respectfully Submitted,

Dated: 10/22/02

By: ______________________

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